

CLAIMS

What is claimed is:

1. A power supply circuit for supplying alternating power to a load, comprising:

a source of direct current (DC) voltage;

a class E amplifier, the class E amplifier receiving the DC input voltage and generating an alternating current (AC) output signal;

a first harmonic filter at the output of the amplifier, the first harmonic filter filtering out predetermined harmonic components of the AC signal to generate a filtered AC signal; and

an output circuit at the output of the first harmonic filter for receiving the filtered AC signal and feeding the filtered AC signal to a load, wherein the output circuit includes a rectifier connected relative to a point in the output circuit such that if the voltage at the point exceeds a predetermined threshold, the rectifier conducts to cause at least one of voltage and current to return to the source of DC voltage and clamps the point to a predetermined voltage.

2. The apparatus of claim 1 wherein the output circuit includes a rectifier connected in parallel with the load.

3. The apparatus of claim 1 wherein the first harmonic filter includes an inductor and a capacitor in series, and the first harmonic filter is placed in parallel with a switch of the amplifier.

4. The apparatus of claim 1 wherein the first harmonic filter includes an inductor and a capacitor, and the inductor is placed between an output of a switch of the amplifier and a terminal of the rectifier.

5. The apparatus of claim 1 wherein the rectifier further comprises a diode, and the first harmonic filter includes an inductor and a capacitor, and the inductor is placed between an output of the amplifier and a cathode of the diode.

6. The apparatus of claim 1 further comprising a plurality of amplifiers arranged in parallel.

7. The apparatus of claim 1 further comprising a second harmonic filter arranged in parallel with the load, the second harmonic filter further filtering out predetermined harmonic components from the filtered AC signal.

8. A power supply circuit for supplying alternating power to a load, comprising:

a source of direct current (DC) voltage;

a pair of class E amplifiers for receiving the DC input voltage and for generating an alternating current (AC) output signal, the class E amplifiers being arranged in a push-pull configuration;

a first harmonic filter at the output of each amplifier, the first harmonic filter filtering out predetermined harmonic components of the AC signal to generate a filtered AC signal; and

an output circuit at the output of each first harmonic filter for receiving the filtered AC signal and feeding the filtered AC signal to a load, wherein the output circuit includes a rectifier connected relative to a point in the output circuit such that if the voltage at the point exceeds a predetermined threshold, the rectifier conducts to cause at least one of voltage and current to return to the source of DC voltage and clamps the point to a predetermined voltage.

9. The apparatus of claim 8 wherein each amplifier comprises:

a switch connected to a first rail of the DC voltage source; and

a resonant circuit connected between the first and a second voltage rail of the DC voltage source, wherein operating the switch energizes the resonant circuit.

10. The apparatus of claim 9 wherein the resonant circuit further comprises:

an inductor connected between the switch and the second rail of the DC voltage source; and

a capacitor in parallel with the switch.

11. The apparatus of claim 9 further comprising a second harmonic filter at the output of the first harmonic filter, the second harmonic filter removing harmonic components from the filtered AC signal to generate an output signal.

12. The apparatus of claim 11 wherein the second harmonic filter comprises an inductor arranged in parallel with the load.

13. The apparatus of claim 11 further comprising a blocking capacitor at the output of the second harmonic filter for removing DC components from the output of the second harmonic filter.

14. The apparatus of claim 8 wherein the first harmonic filter includes an inductor and a capacitor in series, and the first harmonic filter is arranged in parallel with the switches of the amplifiers.

15. The apparatus of claim 9 wherein the first harmonic filter includes an inductor and a capacitor, and the inductor is arranged between an output of the switch and a terminal of the rectifier.

16. The apparatus of claim 15 wherein the second harmonic filter includes an inductor, and the inductor is arranged in parallel with the load.

17. The apparatus of claim 9 wherein the amplifiers further comprises a plurality of amplifiers arranged in parallel with the load.

18. The apparatus of claim 9 wherein each amplifier forms a circuit half and a transformer interconnects each circuit half.

19. The apparatus of claim 18 wherein a second transformer interconnects the output of each circuit half with the load, thereby providing a balanced load.

20. A power supply circuit for supplying alternating power to a load, comprising:

a source of direct current (DC) voltage;

a pair of class E amplifiers arranged in parallel for receiving the DC input voltage and for generating an alternating current (AC) output signal;

a first harmonic filter at the output of the amplifiers, the first harmonic filter filtering out predetermined harmonic components of the AC signal to generate a filtered AC signal; and

an output circuit at the output of each first harmonic filter for receiving the filtered AC signal and feeding the filtered AC signal to a load, wherein the output circuit includes a rectifier connected relative to a point in the output circuit such that if the voltage at the point exceeds a predetermined threshold, the rectifier conducts to cause at least one of voltage and current to return to the source of DC voltage and clamps the point to a predetermined voltage.

21. The apparatus of claim 20 wherein each amplifier further comprises:

a switch connected to a first rail of the DC voltage source; and

a resonant circuit connected between the first and a second voltage rail of the DC voltage source, wherein operating the switch energizes the resonant circuit.

22. The apparatus of claim 21 wherein the resonant circuit further comprises:

an inductor connected between the switch and the second rail of the DC voltage source; and

a capacitor in parallel with the switch.

23. The apparatus of claim 21 further comprising a second harmonic filter at the output of the first harmonic filter, the second harmonic filter removing harmonic components from the filtered AC signal to generate an output signal.

24. The apparatus of claim 23 wherein the second harmonic filter comprises an inductor arranged in parallel with the load.

25. The apparatus of claim 23 further comprising a blocking capacitor at the output of the second harmonic filter for removing DC components from the output of the second harmonic filter.

26. The apparatus of claim 25 wherein the first harmonic filter includes an inductor and a capacitor in series, and the first harmonic filter is arranged in parallel with the switches of the amplifiers.

27. The apparatus of claim 23 wherein the first harmonic filter includes an inductor and a capacitor, and the inductor is arranged between an output of the switch and a terminal of the rectifier.

28. The apparatus of claim 27 wherein the second harmonic filter includes an inductor, and the inductor is arranged in parallel with the load.

29. The apparatus of claim 20 further comprising a second pair of class E amplifiers, each of the second pair of class E amplifiers being arranged in parallel with the first pair of class E amplifiers.

30. The apparatus of claim 29 wherein each pair of amplifiers forms a circuit half and transformer interconnects each circuit half.

31. The apparatus of claim 30 further comprising a second transformer interconnecting the output of each circuit half with the load, thereby providing a balanced load.

32. A plasma control system comprising:
- a plasma chamber excited by a radio frequency (RF) signal;
 - a plasma controller for measuring operating conditions of the plasma chamber and generating control signals for varying conditions within the plasma chamber; and
 - a RF generator for generating an RF signal to the plasma chamber, the RF generator including:
 - a RF controller, the RF controller receiving the control signal from the plasma controller and generating a power supply control signal, and
 - a power supply for receiving the power supply control signal and generating a RF signal in accordance with the power supply control signal, the power supply including:
 - a source of direct current (DC) voltage;
 - a class E amplifier, the class E amplifier receiving the DC input voltage and generating an alternating current (AC) output signal; and
 - a first harmonic filter at the output of the amplifier, the first harmonic filter filtering out predetermined harmonic components of the AC signal to generate a filtered AC signal;
- wherein the power supply includes a protection circuit including a rectifier connected relative to a predetermined point such that if the voltage at the point exceeds a predetermined threshold, the rectifier conducts to clamp the voltage at the point to a predetermined voltage.

33. The apparatus of claim 32 wherein the output circuit returns at least one of voltage and current to return to the amplifier.